AIRS in the GEOS-5 Data Assimilation System

Ron Gelaro

Emily Hui-Chun Liu and Ivanka Stajner

Global Modeling and Assimilation Office
NASA/GSFC

AIRS Science Team Meeting
27 September 2006

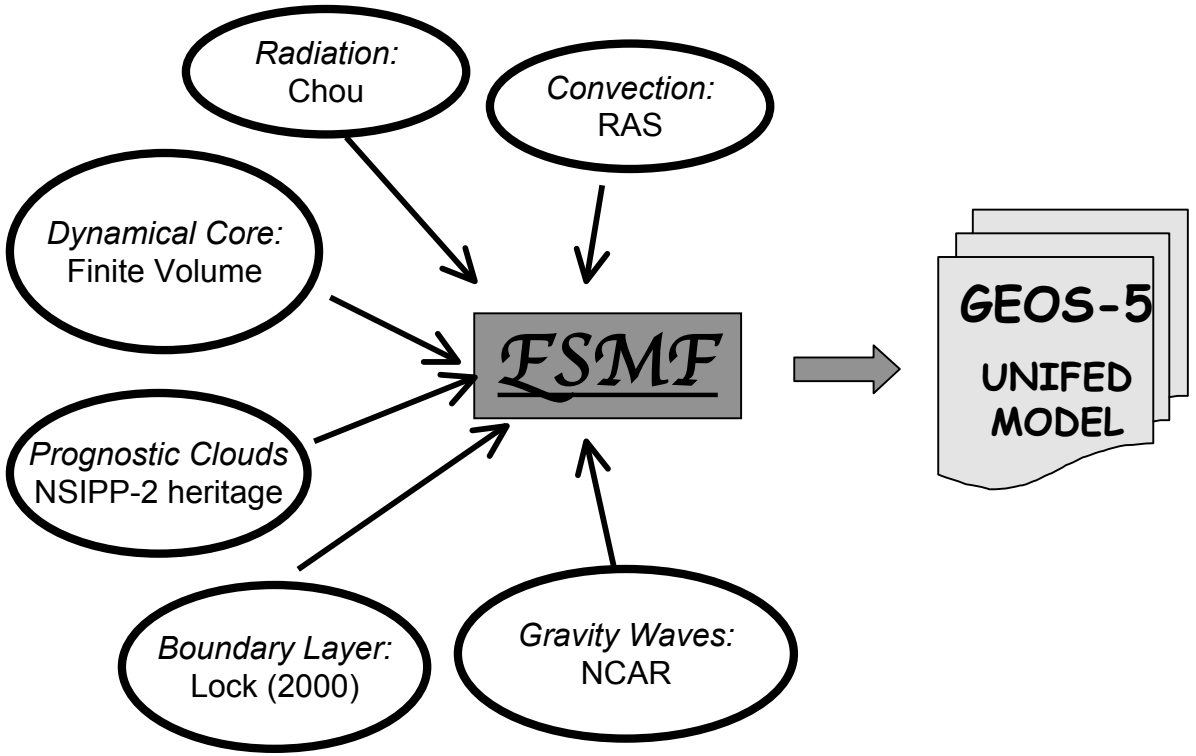
- GEOS-5

- AIRS impacts on forecasts evaluated using adjoint sensitivity tools

- AIRS moisture channels and ozone analyses

GEOS-5
Data Assimilation
System

The MODEL:

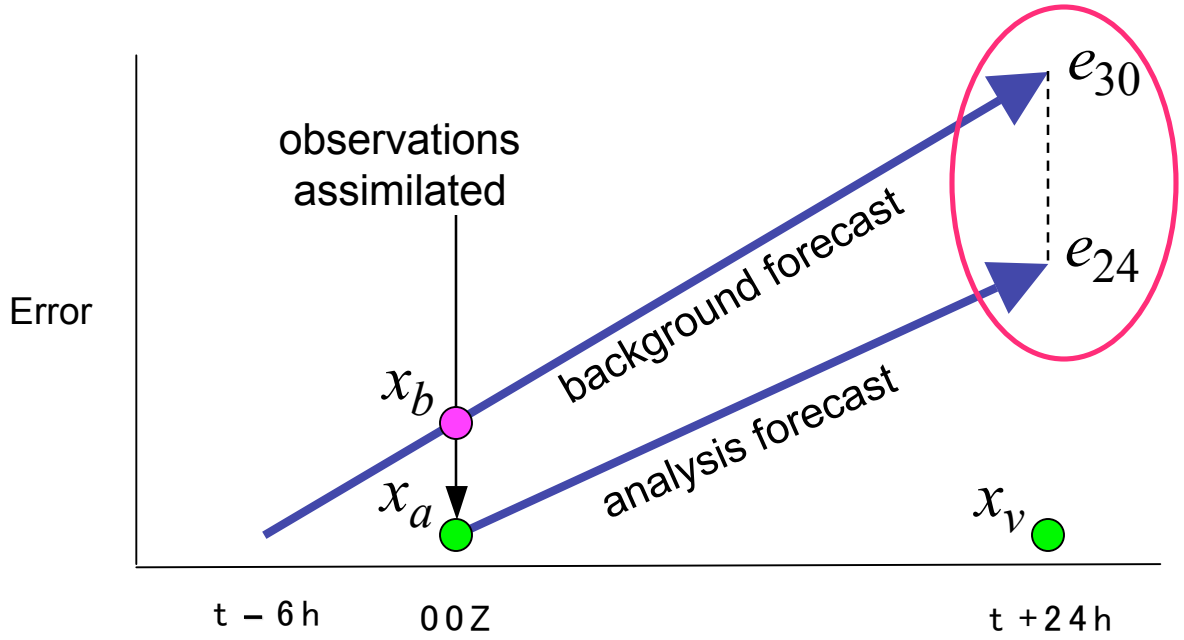


The ANALYSIS:

NCEP-GMAO's Gridpoint Statistical Interpolation (GSI) analysis
- Radiance-based assimilation
- Adaptive observational bias correction
- Online model bias correction
- JCSDA's CRTM

ADJOINT versions of the MODEL and ANALYSIS have been developed

Using Adjoints to Assess Observation Impact on Forecast Error

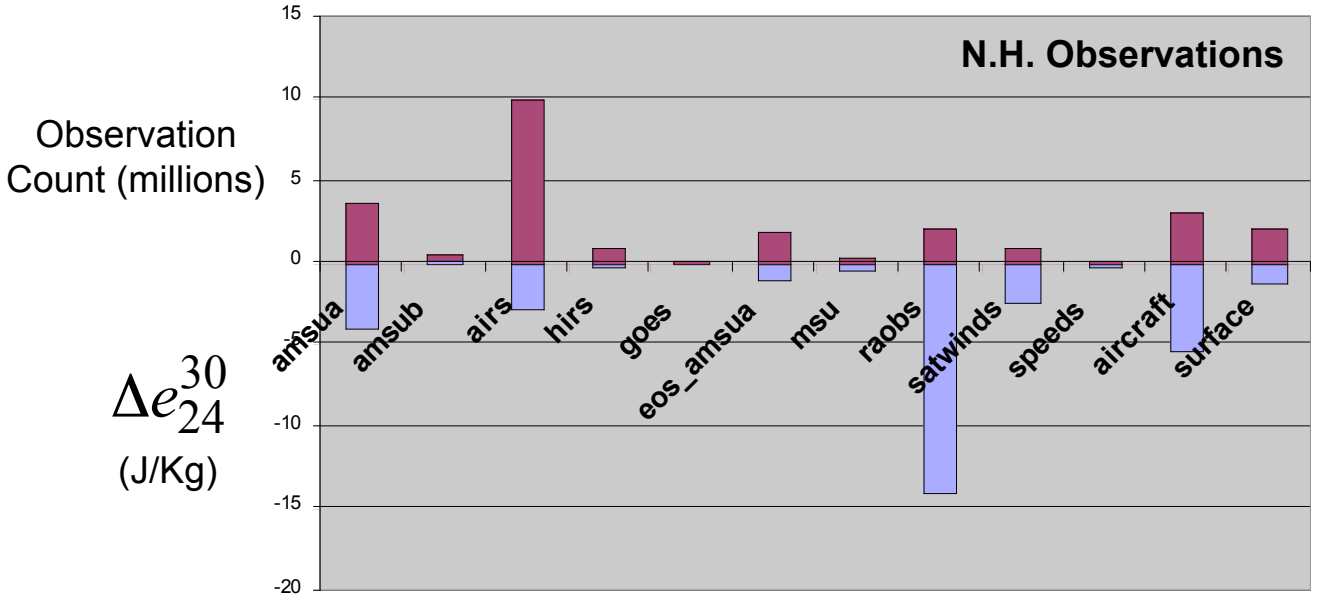


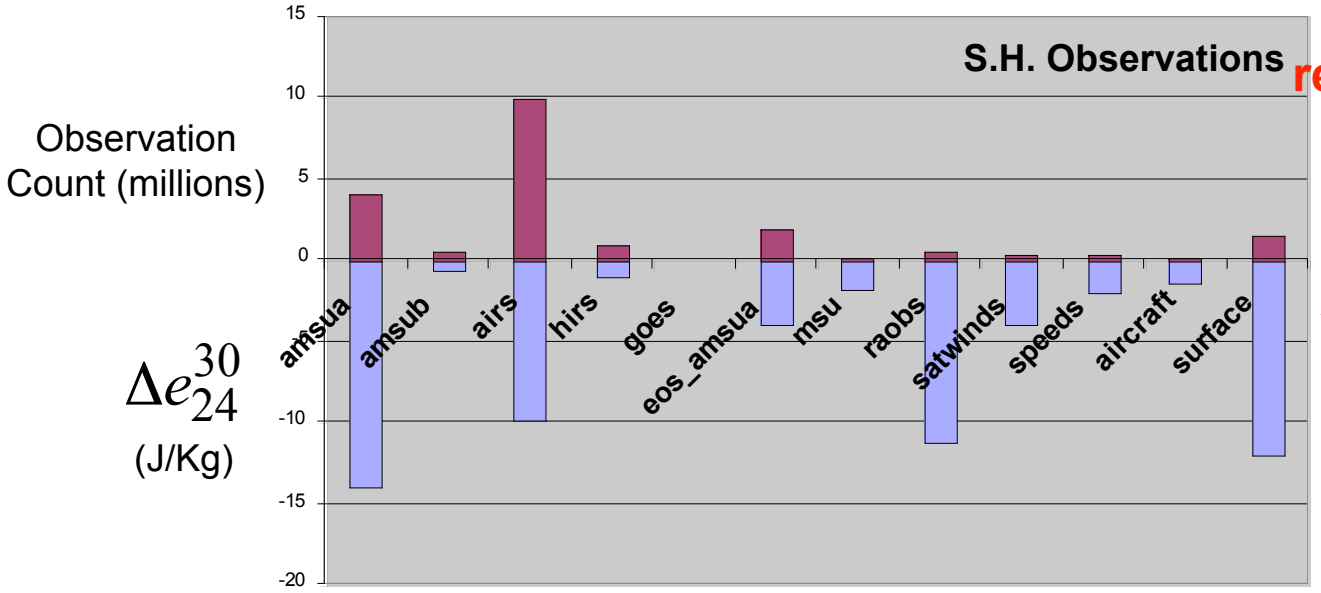
- The difference $e_{24} - e_{30} = \Delta e_{24}^{30}$ is due entirely to the assimilation of observations at 00Z $\Rightarrow$ *measures the impact of the observations*

- $\Delta e_{24}^{30} < 0$ indicates that the error of the forecast started from x_a is less than that started from x_b $\Rightarrow$ *the observations are beneficial*

- Δe_{24}^{30} can be estimated as a sum of *contributions from individual observations* using information from the model and analysis adjoints together

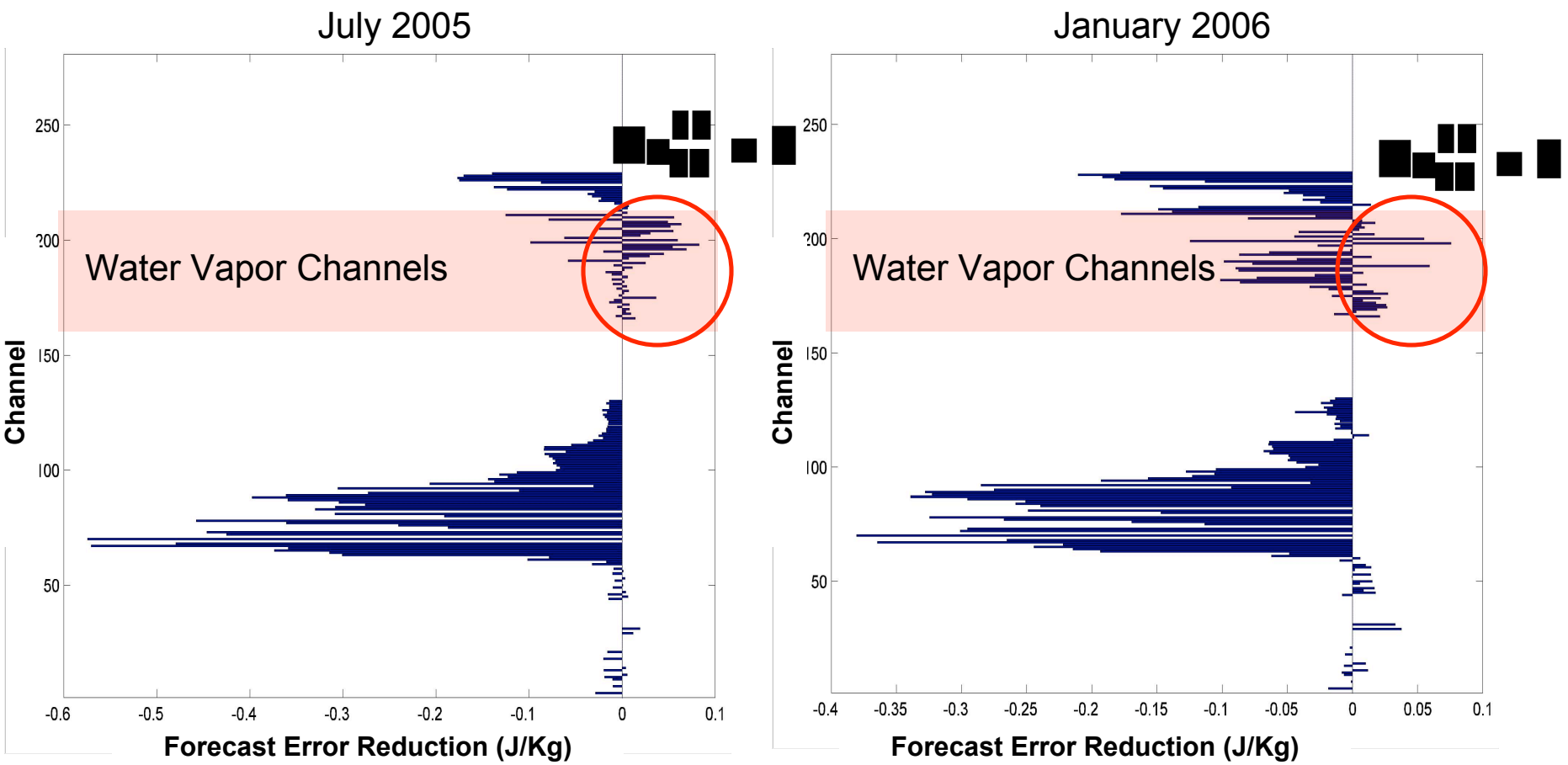
GEOS5 Observation Impact: July 2005 00z Totals





…all observing systems provide overall benefit: reduce 24h global forecast error

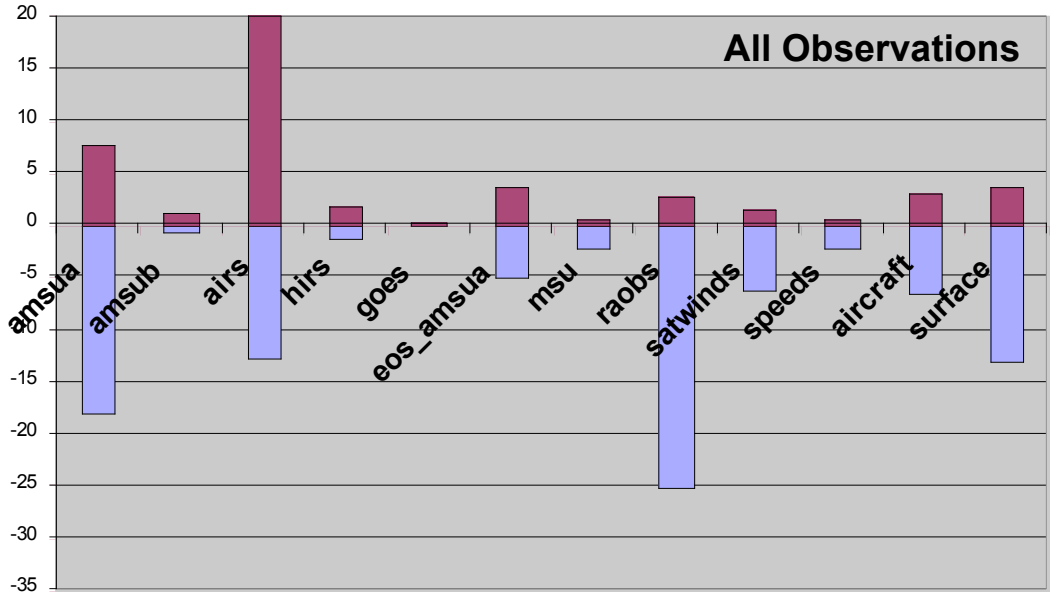
GEOS5 Observation Impact: Totals for AIRS Channels



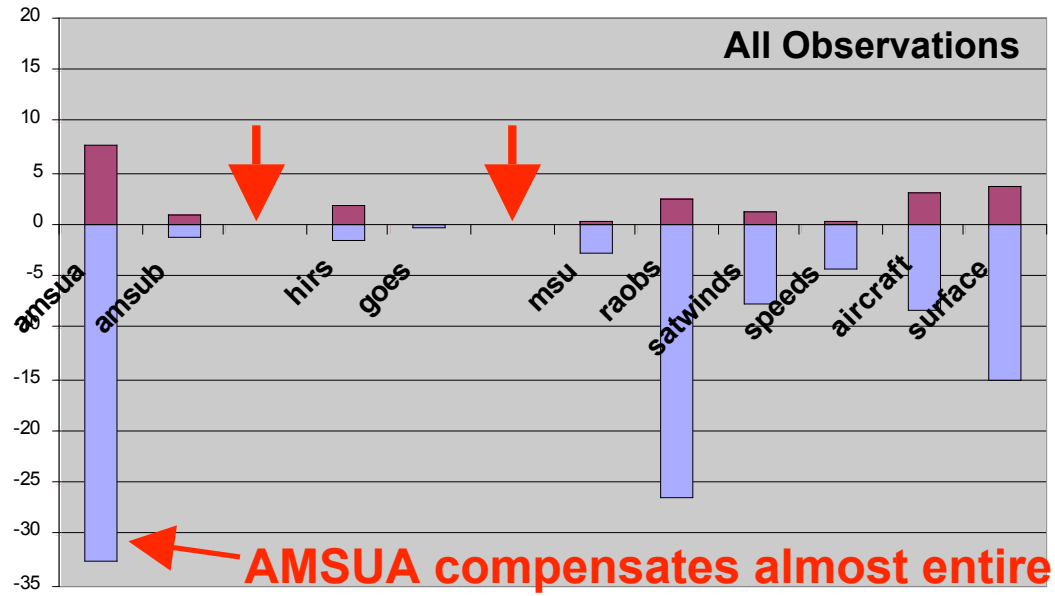
A significant fraction of AIRS water vapor channels currently degrade the 24-h forecast in GEOS-5…investigation under way.

GEOS5 Observation Impact: July 2005 00z

Totals for AQUA data denial experiments



Control All Data

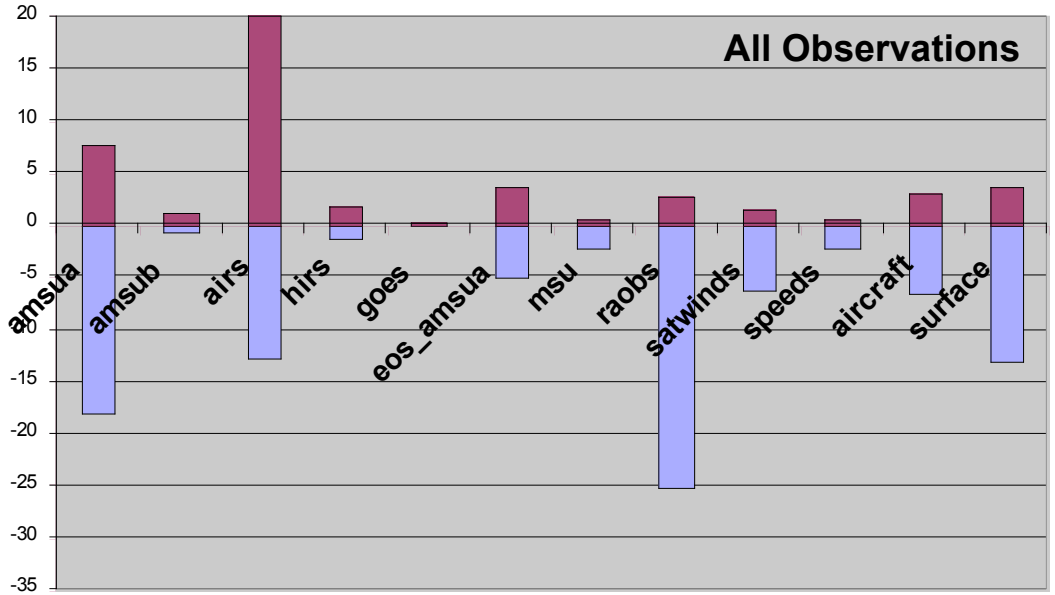


Without AQUA AIRS+AMSUA

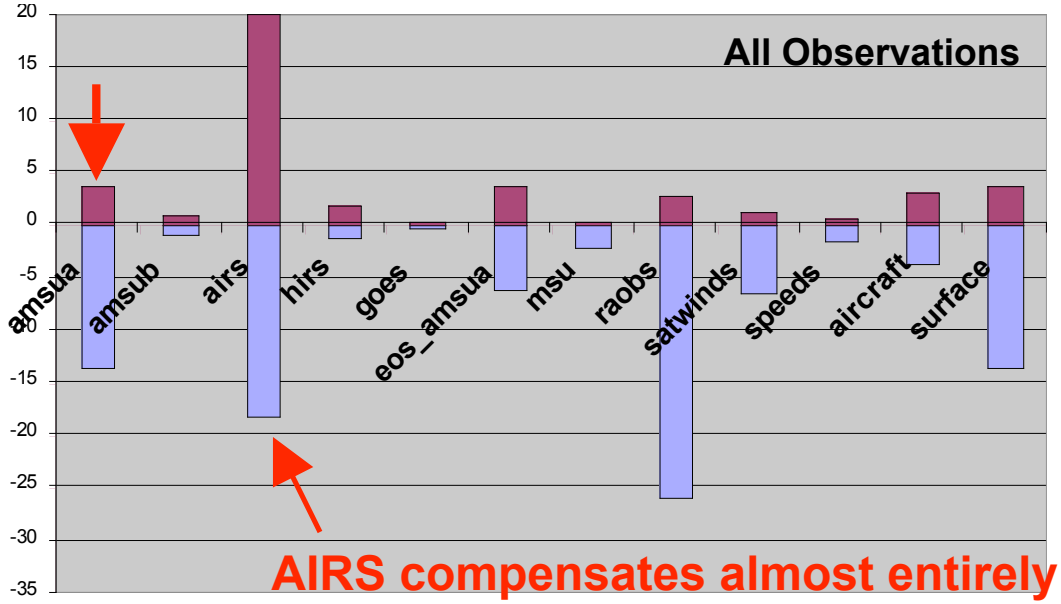
AMSUA compensates almost entirely for AQUA data

GEOS5 Observation Impact: July 2005 00z

Totals for AMSUA data denial experiments



Control All Data



Without NOAA16 AMSU-A

AIRS compensates almost entirely for AMSUA data

Ozone in GEOS-5 DAS

Data:

- **SBUV** and **OMI** ozone
- **TOVS** and **AIRS** radiances
- plan to include **MLS** retrieved stratospheric ozone profiles

Model:

- Transport in GCM
- Parameterized chemistry (production and loss rates)

GSI-model interface uses Incremental Analysis Update

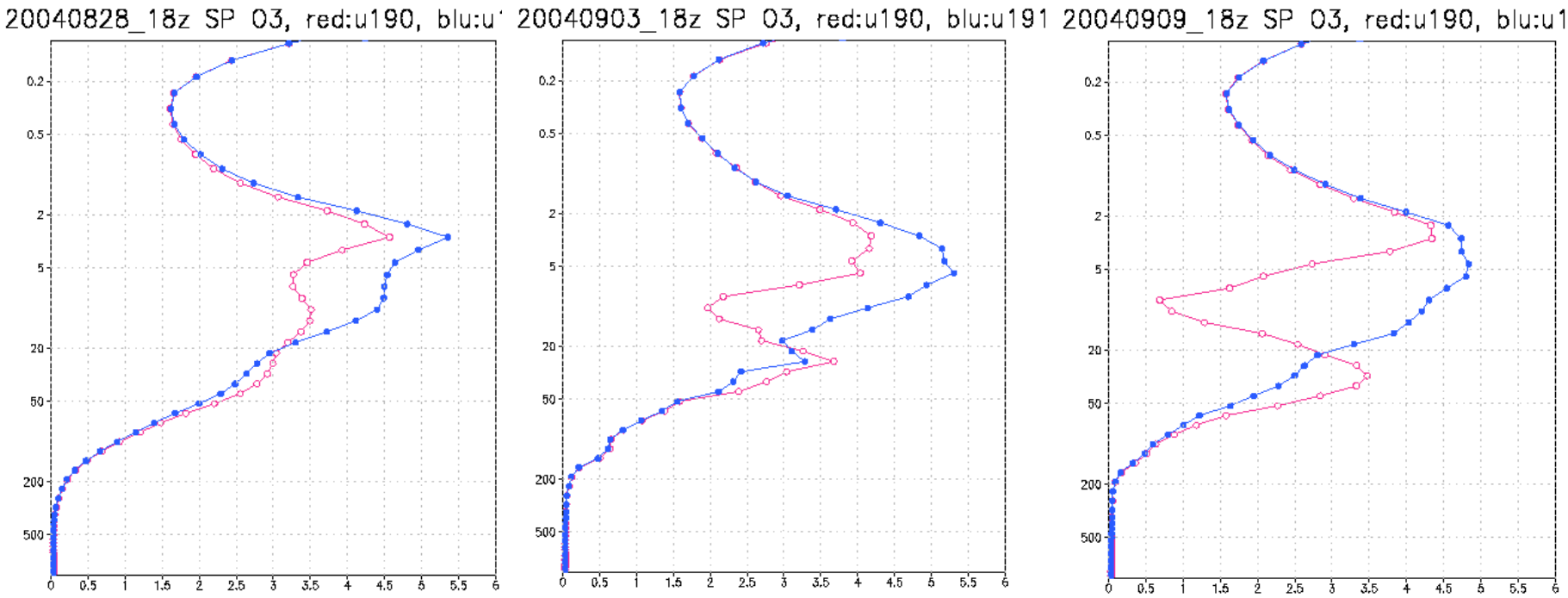
Prognostic ozone used in:

- Radiative heating computations in GCM
- Assimilation of IR radiances

AIRS and polar ozone

- In standard configuration AIRS ozone channels (around 9.6 μm) are not used.
- Other AIRS channels are sensitive to ozone.
- AIRS has an adverse impact on GEOS-5 ozone during polar night
  - No SBUV or OMI data present
  - GSI increments from AIRS systematically reduce ozone
  - Increments arise from AIRS water vapor channels
  - Increments coincide with polar stratospheric clouds
- Problem larger in the Antarctic, but also seen in the Arctic.

Impact of AIRS in polar night

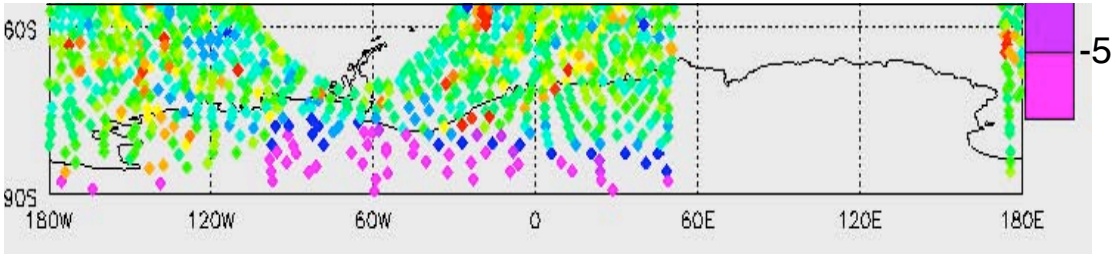


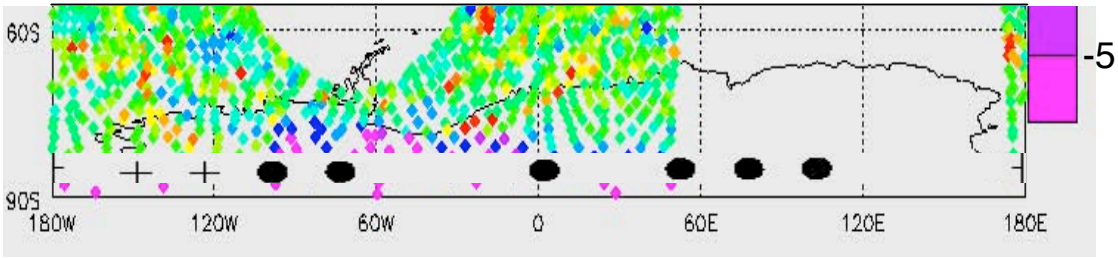
Runs start on August 27, 2004

GEOS-5 crashed in GCM on Sept. 10

- Ozone profiles at South Pole
- 152 AIRS channels used: not ozone channels 1003-1285
- Red – other AIRS channels impact ozone
- Blue – impact of AIRS on ozone turned off

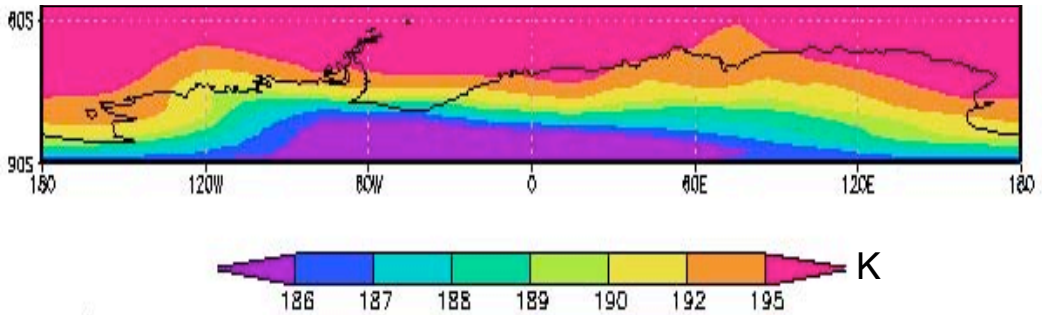
AIRS O-F residuals in channel 191 (6.79μm) on 20040908z00





POAM observations: + no thick PSCs, ● thick PSCs

Temperature at 100 hPa on 2004090718z



Ozone: status and plans

- AIRS ozone assimilation in GEOS-5 highlights the complex interactions between the model, data and analysis methodology

- GEOS-5 development
  - Modify quality control for AIRS moisture channels to eliminate PSC-contaminated data
  - Include AIRS ozone channels with appropriate quality control

- AIRS moisture channels are being exploited to generate maps of thick PSCs...lead to eventual improvement in detection of PSCs…

SUMMARY

• Preliminary impact experiments show that AIRS has a small positive impact on forecast skill in GEOS-5

• Adjoint results indicate that forecast impact of moisture channels is mixed…may reflect problems in current analysis of moisture

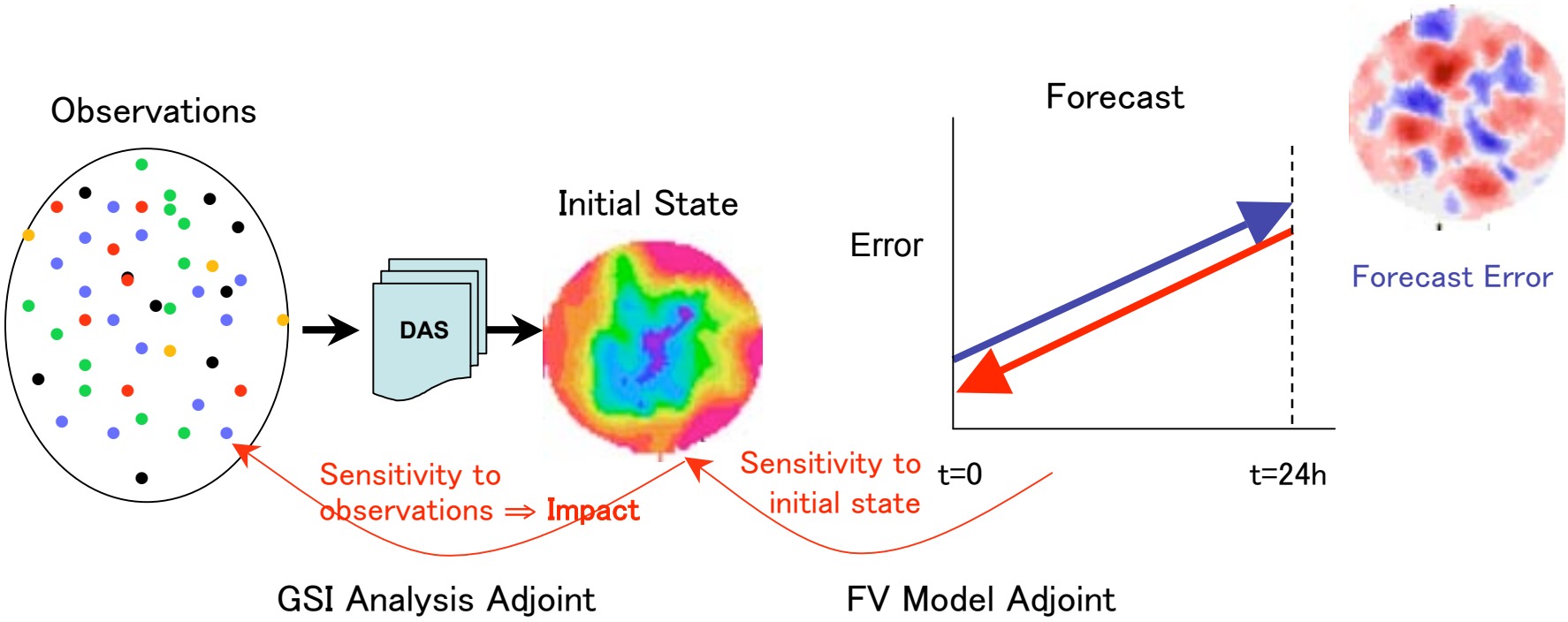
• Working to improve data selection strategies…adjoint shows some redundancy is evident (but this is not necessarily bad)

• Ozone analysis in GEOS 5 provides a sensitive test for assimilation of AIRS radiances. Quality control is being modified to eliminate data that would corrupt ozone impact.

END

Adjoint tools: Providing information on the impact of observations

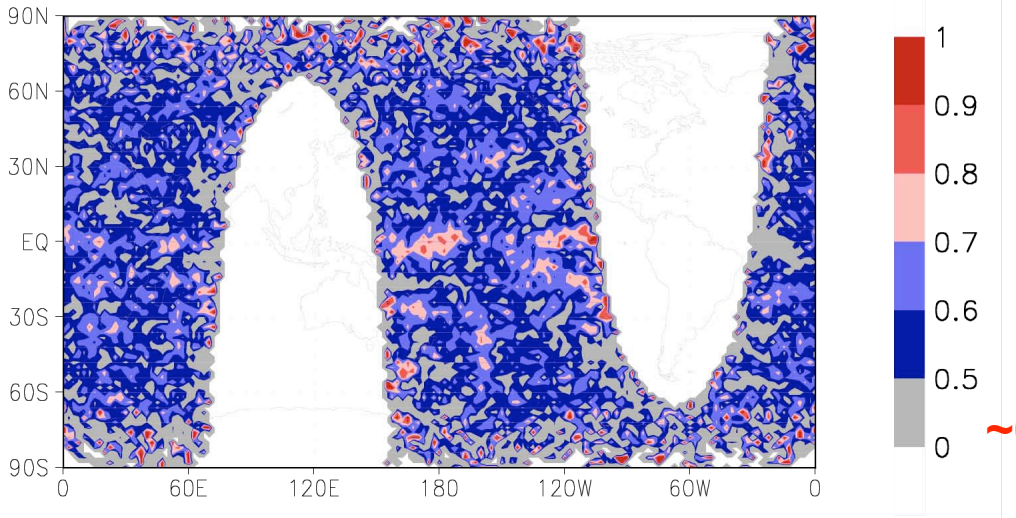
- Efficient estimation of sources of forecast error and observation sensitivity (observation impact)
  - ❖ determined with respect to observational data, background fields or assimilation parameters, all computed simultaneously
  - ❖ useful for designing intelligent data selection strategies and guiding future observing system design



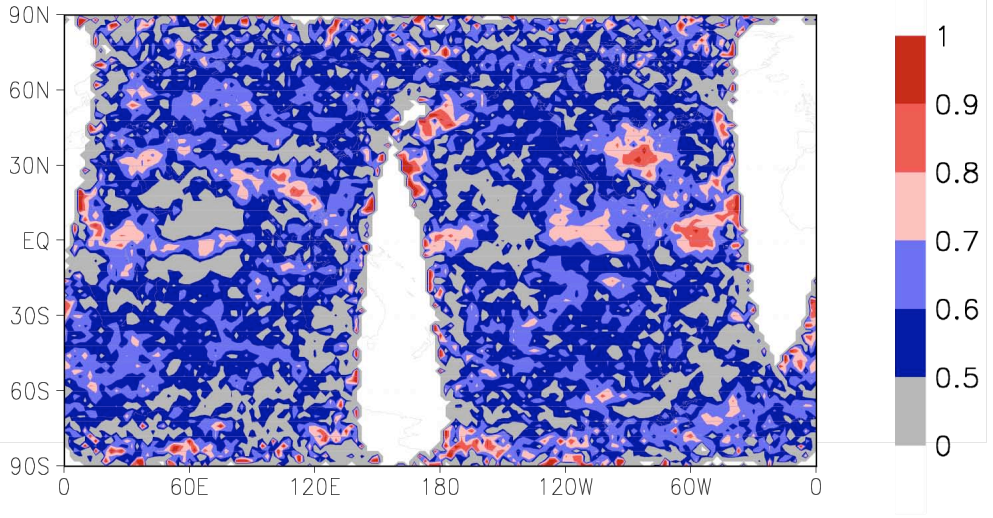
GEOS5 Observation Impact: July 2005 00z

Fraction of observations that provide benefit to 24h forecast

AIRS



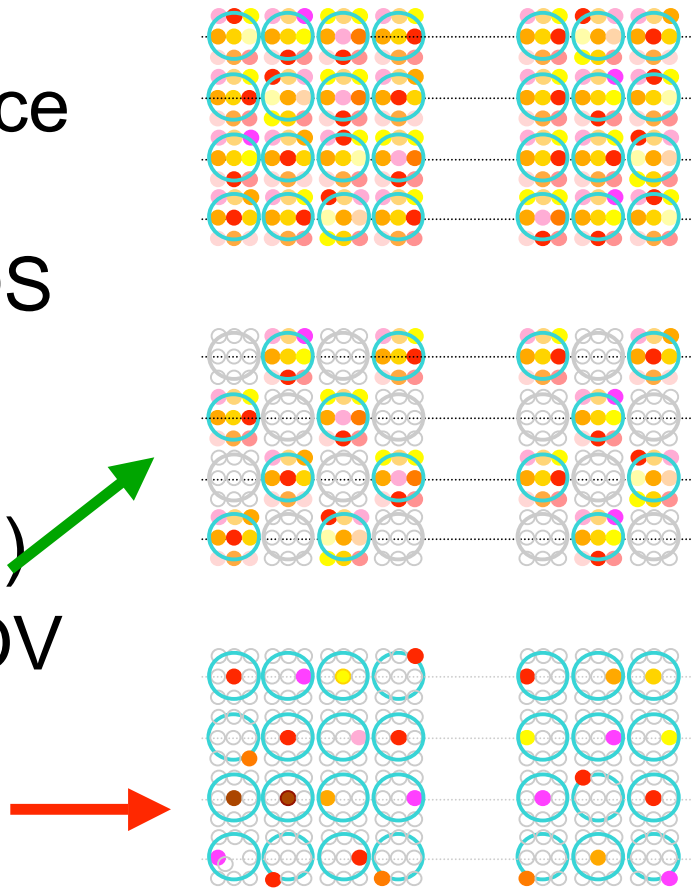
AMSU-A
NOAA15, NOAA16



~60% of satellite observations assimilated provide benefit

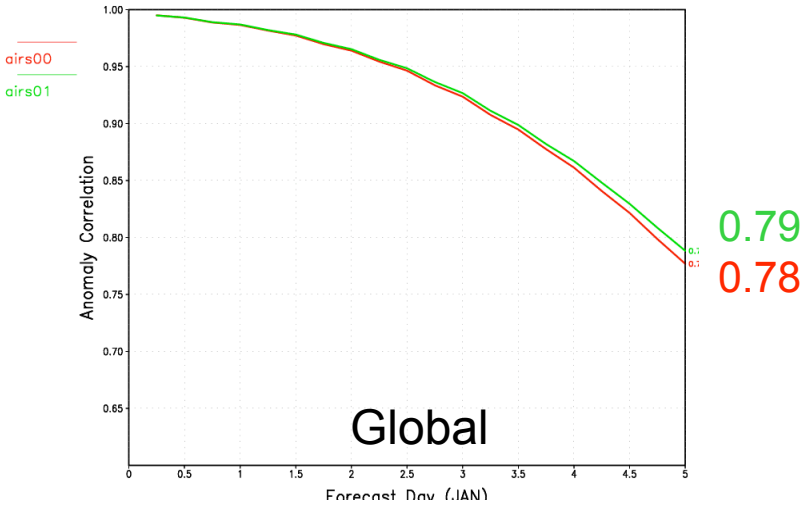
In House Aqua AIRS/AMSU-A Data Processing

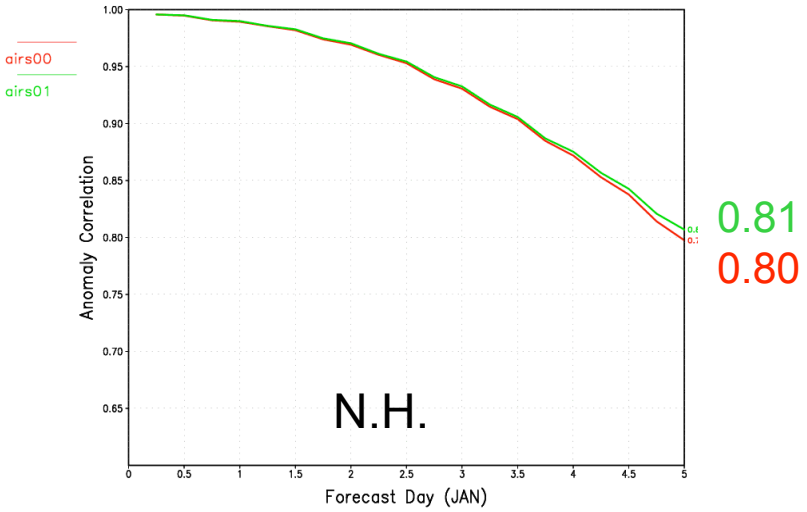
- Began to receive 281 channel **full spatial resolution** AIRS/EOS AMSU-A data from NESDIS since December 15 2005
- Process full resolution AIRS/EOS AMSU-A data into two different subsets
  - **Thinned** (every other golfball)
  - **Warmest** (Warmest AIRS FOV in every golfball)

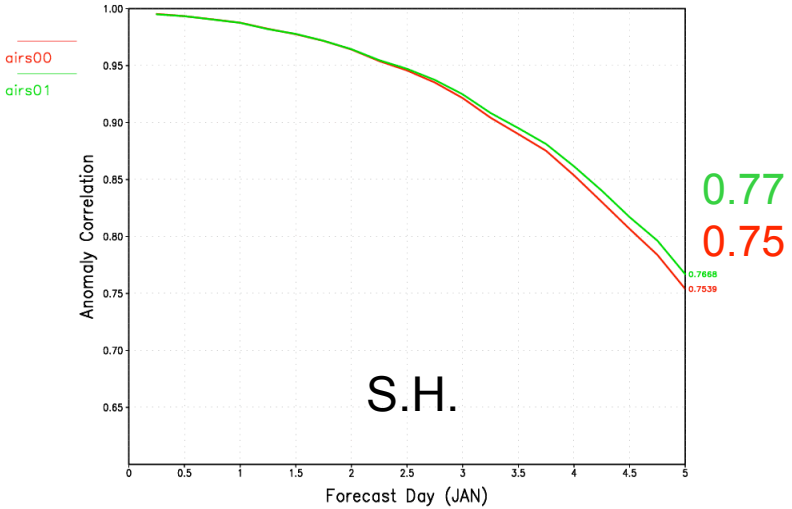


AIRS Impact on GEOS-5 Forecasts

January 2006





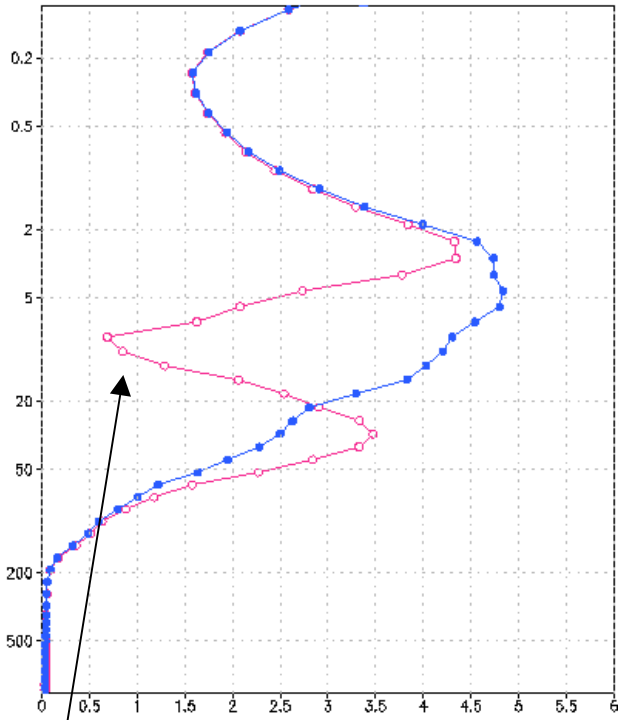


- 251 channels, all FOVs
- Resolution: ~0.5° x 72 levels
- No AIRS (red) vs. AIRS (green)
- Small positive impact both hemispheres

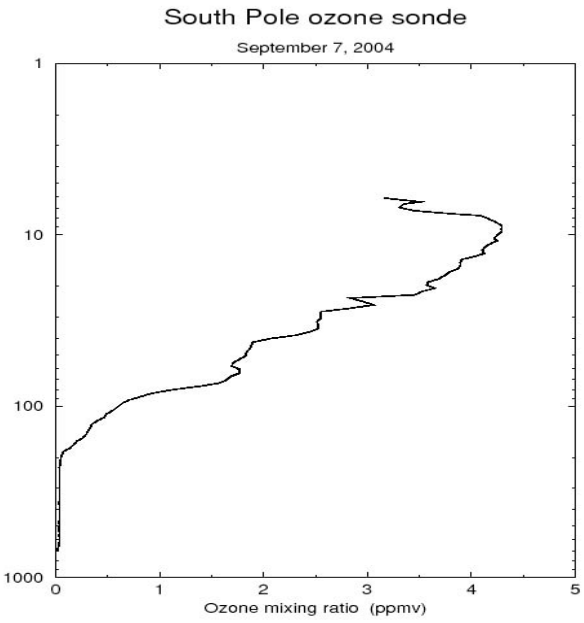
Beta7p1

Comparisons with sonde and MLS

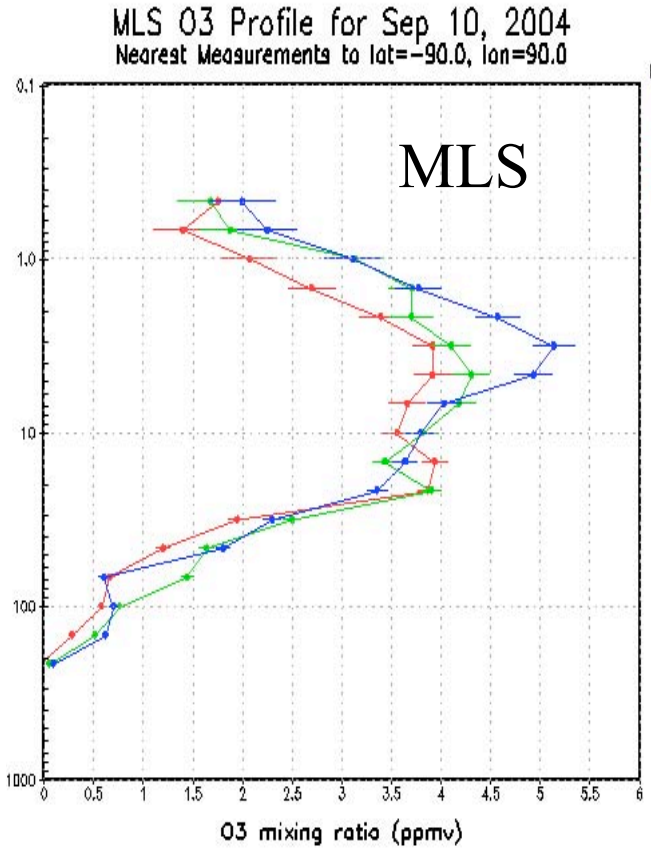
Analyses on 20040909



South Pole ozone sonde



MLS

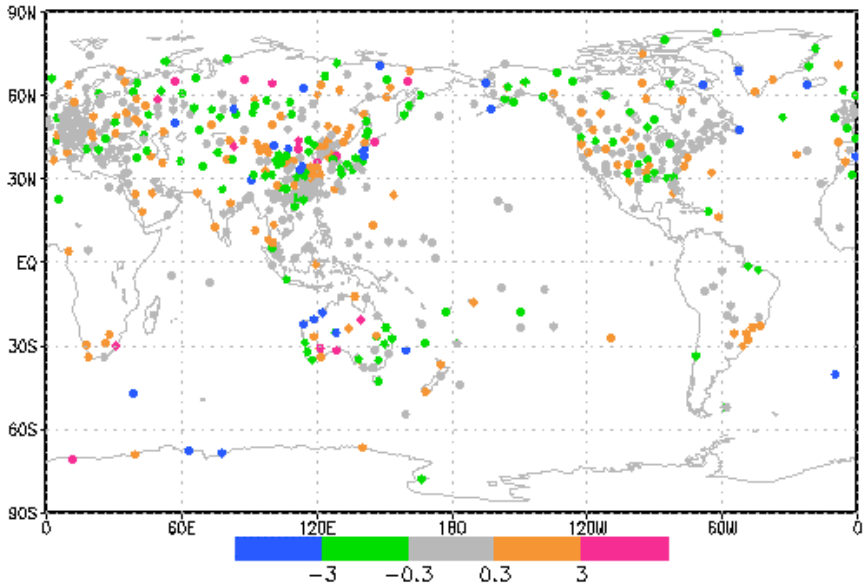


- No support for structure in ozone profile coming from assimilation of AIRS

Observation Impact on GEOS-5 24h Forecast Error

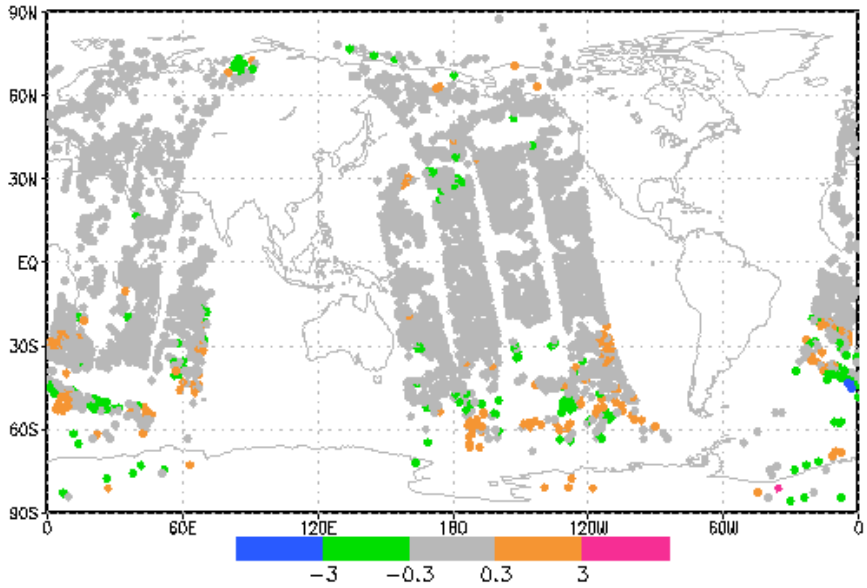
Impact of 500mb RAOB Temps

10 July 2005 00z



Impact of AIRS Ch.221 Radiances

10 July 2005 00z



- Observations that reduced the 24h forecast error: $\Delta e_{24}^{30} < 0$
- Observations that increased the 24h forecast error: $\Delta e_{24}^{30} > 0$
- Observations that had small impact on 24h forecast error